

THE REFLEXES IN LONG DISTANCE RUNNERS. A STUDY
OF THE INFLUENCE OF FATIGUE UPON CERTAIN
REFLEXES.¹

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As is well known, one of the more interesting events of the revival of the Olympic games at Athens in 1896 was the foot race from Marathon to Athens, a distance of forty kilometres, in commemoration of the exploit of Eucles, the soldier who is said to have run in full armor from the battle-field to Athens with the news of victory, and dropped dead in the market-place as he told his story. Some of the American contestants in that event established a "Marathon run" in Boston under the auspices of the Boston Athletic Association, which has for seven years been one of the features of Patriot's Day, April 19th, and has become an athletic event of considerable importance.

During five of these seven years the participants in the runs have kindly lent themselves to the investigations of a large number of physicians, and the results of these investigations have been published by Drs. Williams and Arnold² and Drs. Blake and Larrabee.³ These investigations have been directed toward the weight, pulse, temperature, pulse tracing, the blood, the heart and the kidneys.

The course is twenty-four miles (forty kilometres), from Ashland to Boston, the first two-thirds of the way over ordinary country roads, the last third over the hard macadamized roads of the

¹Read at the meeting of the American Neurological Association, May 12, 13 and 14, 1903.

²Philadelphia Med. Journal, June 3, 1899.

³Boston Med. and Surg. Journal, Feb. 19, 1903.

Boston park system. There are several rather trying hills. The men must proceed on foot over the entire distance, without any assistance, but they may eat or drink what they please during the race. Each contestant is usually accompanied by several men on bicycles. As soon as the men arrive at the goal—the club-house of the Athletic Association—they are taken in the elevator to the examining room, where the second series of examinations is made. The first examinations are made at the hotel at Ashland an hour or two before the start. The men are young, of various nationalities and callings, and are classed as “amateurs.” The time of the winner has varied from two and a half to three hours.

In addition to the physical strain attendant upon this run of twenty-four miles there must be considerable mental excitement. For two hours before the race the little hotel at Ashland is crowded with the contestants, their trainers and attendants, and the corps of examining physicians, a dozen or twenty men crowded into each little room. The village street outside is full of automobiles, bicycles, and interested spectators. Large and enthusiastic crowds assemble in all the towns through which they pass. The newspaper estimates of the number of spectators vary from one to two hundred thousand. For the last mile or two, in the city itself, the streets are packed with thousands of cheering spectators, through which the mounted police, the automobiles and the bicycle guards of the runners can with difficulty make their way.

In the contest this year an attempt was made to study the conditions of certain reflexes in these contestants before and after the run. For this purpose the following reflexes were selected: Plantar reflex, knee-jerk, ankle-reflex, front-tap contraction, ankle-clonus and patellar clonus. The reflexes were examined in both legs in each contestant, the legs being bare.

Forty-eight men were examined at Ashland before the run. Of these forty-one presented themselves for re-examination at the Athletic Club after the run, but four or five of them had not covered the whole course. The winner, unfortunately, escaped our examination at Ashland, but he kindly presented himself for examination five days later.

It is self evident that in examining so large a number of men

in a limited time the use of elaborate apparatus is impossible. Nor is it safe to rely on a simple estimate of "increased" or "diminished" for purposes of comparison. In our investigations, therefore, we adopted a scale, modified from one proposed some years ago by Kidd. Before describing this, however, a word of explanation is necessary in regard to one term. In the ordinary test for the patellar clonus, when the patella is drawn downward by the finger and the finger struck with a percussion hammer, or better, with Taylor's reflex hammer, the quadriceps extensor will often give one contraction, even when there is no clonus. This we have called the "patellar twitch." It is often present in cases where the knee-jerk is fairly lively, yet where there is no front tap contraction. On the other hand, front tap contraction is rarely, if ever, present when there is no patellar twitch. The scale we adopted, then, was as follows:

1. Knee-jerk absent = $Kj - 3$ or $Kj 0$.
2. Knee-jerk obtained only by re-enforcement = $Kj - 2$.
3. Knee-jerk obtained without re-enforcement, but very slight, = $Kj - 1$.
4. Fair knee-jerk = Kj normal.
5. Knee-jerk with patellar twitch = $Kj + 1$.
6. Knee-jerk with patellar twitch and front tap contraction = $Kj + 2$.
7. Knee-jerk with patellar and ankle clonus = $Kj + 3$.

TABLE I.
Condition of the knee-jerk before the run.

$Kj - 2$	1
$Kj - 1$	4
$Kj + 1$	26
$Kj + 2$	18

The conditions of the reflexes in these forty-nine men before the run were of some interest. As might fairly be predicted, the knee-jerk and ankle-reflexes were present in every case, and only in one instance was re-enforcement necessary to obtain the knee-jerk. It was a somewhat curious fact, however, that the degree of ankle-reflex remained rather constant. It seldom showed the variations of the knee-jerk. In no case was there ankle or patellar clonus, although one man had a very slight spurious clonus. In the main the knee-jerks were rather exaggerated; twenty-six had

also a patellar twitch, and eighteen a patellar twitch and front-tap contraction.

Whether this exaggeration is to be attributed to excitement, or is characteristic of runners, as Dr. Hammond⁴ has suggested, we can not tell. In no instance was there any inequality of the knee-jerk or ankle-reflex, but in three cases the patellar twitch seemed unilateral and in four the front-tap contraction.

In five cases no plantar reflex was obtained. The method of testing, however, was designedly inadequate. A not very sharp stick was used and no attempt was made to procure the reflex by a sharp steel point, lest the runner's foot might accidentally be scratched and his running power thus diminished. Experience has taught us that the sharp steel point is at times necessary to elicit this reflex in healthy subjects, and we regard the plantar reflex as extremely constant in health. In no case, we may add, was there a Babinski reflex, and in no case was there inequality of the plantar reflexes. No distinction was made between flexion of the toes and the fascia lata reflex, but the former was usually present and both often coexisted.

The influence of fatigue upon the reflexes has been somewhat disputed. Lombard⁵ found that moderate fatigue, such as going over the stairs for fifteen minutes, caused a decided diminution in the knee-jerk, and he explained the discrepancy between his conclusions and Sternberg's⁶ by the fact that Sternberg's observations were made on cases of extreme fatigue. Other writers have in the main agreed with Sternberg's conclusions that the reflexes are exaggerated by fatigue. Subsequently, however, Sternberg⁷ has asserted that while moderate fatigue, as he showed by experiments, increases the reflexes, excessive fatigue diminishes or abolishes them. We have failed to find the experimental evidence of this statement, which has been copied by various writers subsequently (Sherrington,⁸ Oppenheim⁹).

The noteworthy result of our investigation was the discovery

⁴Lancet, March 30, 1895.

⁵American Journal of Psychology, April, 1887.

⁶Centralblatt für Psychologie, i, 81; May 14, 1887.

⁷"Die Schenreflexe," p. 87.

⁸Schäfer, "Text-book of Physiology," ii, 872.

⁹"Lehrbuch der Nervenkrankheiten," p. 14, 3d edition.

that the run, in many cases, namely, twenty-six in number, caused some diminution of the knee-jerk. In four cases only was there an increase, that is, in four cases a front-tap contraction was obtained after the run, although not before. In no case, however, was there a clonus. The diminution was often decided. In three cases, for example, the knee-jerk was absolutely lost, although in all three it had been attended with a patellar twitch before. In one of these cases, however, the man was too exhausted to sit

TABLE 2.
CONDITION OF THE KNEE-JERK AFTER THE RUN.

			CONDITION OF KNEE-JERK BEFORE RUN	ANKLE REFLEX
Kj	0	3	Kj + 1, 3	0, 1; — 1
Kj	— 2	6	Kj — 2, 1; Kj + 1, 4; Kj + 2, 1	0, 1
Kj	— 1	5	Kj + 1, 5	0, 2
Kj	N	4	Kj + 1, 2; Kj + 2, 2	0, 1
Kj	+ 1,	7	Kj + 1, 3; Kj + 2, 4	
Kj	+ 2,	9	Kj N, 1; Kj + 1, 3; Kj + 2, 5	
Kj	unequal	4	Kj N, 1; Kj + 1, 3	
[N, 3; + 1, 1,]				
Kj 0 on one side,			Kj N, 1; Kj + 1, 2	
Kj—2 on other 3				

up, and the knee-jerk had to be taken while lying down and re-enforcing—an inadequate method. In three other cases the knee-jerk was lost on one side and obtainable only by re-enforcement on the other. In five other cases the knee-jerk could be obtained

TABLE 3.
CONDITION OF ANKLE REFLEX AFTER RUN.

ANKLE REFLEX		CONDITION OF KNEE-JERK.
Absent	5	Kj 0, 1; Kj — 2, 1; Kj — 1, 1; Kj N, 1; Kj absent on one side, only by reënförceinent on other, 1
Diminished	2	Kj 0, 1; Kj absent on one side, only by reënförceinent on other, 1
Absent on one side, diminished other	2	Kj 0 one side, only by reënförceinent on other, 1; Kj unequal, normal in degree, 1

only on re-enforcement, and in five more it was diminished. In four cases the knee-jerks became unequal on the two sides.

The ankle-reflexes showed also a diminution. In five cases they were lost, in two they were lost on one side, and in two they were diminished. The loss of ankle-reflex, however, did not always coincide with loss of knee-jerk, or *vice versa*.

As has been indicated above, the minor reflexes, the patellar twitch and front-tap contraction may fairly be cited as indications of the diminution of reflex energy. The patellar twitch, present in forty-four cases before the run, was present in only seventeen after, and the front-tap contraction, present in eighteen before, was present in but nine after.

TABLE 4.
MINOR REFLEXES BEFORE AND AFTER RUN.

	BEFORE	AFTER
Patellar twitch	44 in 49	17 in 41
Front-tap contraction	18 in 49	9 in 41

The plantar reflex, however, showed a different condition. The quantitative changes here must be merely estimates, for no elaborate methods of measurement were feasible. It seemed to us, however, that in a very considerable proportion of the cases there was an increase. Such increase was noted in twenty cases and a diminution in five, while in twelve no change was noted. The correctness of this opinion seems further justified by the results observed in the cases where no reflex was obtained before the run. Four of these five men were examined after the run, and in every case a reflex was obtained. In no case was there a Babinski reflex.

The explanation of the diminution of the tendon reflexes is perfectly simple—the increased sensitiveness of the soles to irritation following the pounding over the hard roads. In many cases there were large blisters on the feet, and it is fair to suppose that the skin elsewhere was unduly sensitive.

The explanation of the exaggeration of the plantar reflex is not so easy. There is probably, as Dr. Larrabee has shown, an acute toxemic condition induced by the run, but acute toxemia as a rule is not accompanied by diminution of the reflexes. The exhaustion, as a rule, was not so great as might have been expected, and the few men who were so much exhausted as to demand special attention, did not show greater changes than the others. Nevertheless, the theory of exhaustion of the reflex centers in the cord seems the most plausible explanation.